Discovery
Agriculture

7(17), 2021

Changes in soil properties at fifty nine (59) days after humanure application and the growth of watermelon in Owerri, Imo state Nigeria

Ekpe II✉, Oti NN, Uju EU, Mgbeahuru CI, Nwankwo VC, Iheka WC

To Cite:
Ekpe II, Oti NN, Uju EU, Mgbeahuru CI, Nwankwo VC, Iheka WC. Changes in soil properties at fifty nine (59) days after humanure application and the growth of watermelon in Owerri, Imo state Nigeria. *Discovery Agriculture*, 2021, 7(17), 110-124

Author Affiliation:
Department of Soil Science and Technology, School of Agriculture and Agricultural Technology, Federal University of Technology Owerri P.M.B 1526 Imo state, Nigeria

✉**Corresponding Author:**
Department of Soil Science and Technology, School of Agriculture and Agricultural Technology, Federal University of Technology Owerri P.M.B 1526 Imo state, Nigeria,
E-Mail: ibiamik@yahoo.com;
Mobile Phone: 08037740280

Peer-Review History
Received: 17 February 2021
Reviewed & Revised: 18/February/2021 to 27/March/2021
Accepted: 29 March 2021
Published: April 2021

Peer-Review Model
External peer-review was done through double-blind method.

DISCOVERY
SCIENTIFIC SOCIETY

ABSTRACT

This research was conducted at the Centre for Agricultural Research and Extension, Federal University of Technology Owerri to determine the effect of humanure on soil properties at Fifty nine (59) days after humanure application and growth of watermelon in Owerri Imo State Nigeria. The experiment comprised of five (5) treatments namely, T1 - Control = 0t/ha, T2 - NPK=240kg/ha, T3 - Humanure =10t/ha, T4 - Humanure =15t/ha, T5 - Humanure = 20t/ha. The experiment was laid out in a Randomized Complete Block Design (RCBD) with the treatments replicated three (3) times to give a total of fifteen (5) plots. The test crop used was watermelon (Kaolack specie). Humanure treatment was incorporated into the soil two (2) weeks before planting. Watermelon seeds (Kaolack specie) were sown at the spacing of 70cm×70cm. Weeding was carried out two (2) weeks after planting and subsequently as regularly as the need arose. Raw data obtained was analyzed using analysis of variance (ANOVA) and significant means were separated using Fisher least significant difference (F-LSD) at probability level of P=0.005.The result showed that application of humanure at different rates (10t/ha, 15t/ha and 20t/ha) significantly decreased soil bulk density, increased total porosity and moisture content compared to the NPK treated plot and control. Also application of humanure at the rates of 10t/ha, 15t/ha and 20t/ha improved soil pH, total nitrogen, organic matter, exchangeable cations, effective cation exchange capacity, percentage base saturation and decreased the soil exchangeable acidity relative to the NPK treated plot and the control. Growth parameters of watermelon also increased with increasing rates of humanure treatment with the highest increase recorded in the 20t/ha humanure treated plot. Therefore 20t/ha of humanure treatment could be recommended for farmers in Owerri and places with same soil characteristics for better result of watermelon production.

Key Words: Growth, Humanure, Properties, Soil, Watermelon.

ISSN 2347–3819 EISSN 2347–386X | OPEN ACCESS

1. INTRODUCTION

The challenge of producing adequate food for the ever increasing population in Nigeria, demands exploring and expanding new frontiers of research. Traditionally agriculture relies heavily on mineral fertilizer (NPK) for crop production in Nigeria and other developing countries (Nwite, 2015) and incidentally, use of fertilizer is confronted with problems of unavailability, high cost and increase in soil acidity. As a result, use of fertilizer has become inefficient and there is need for its alternative source. Organic manure has been identified as a reliable alternative to reduce continued large scale use of mineral fertilizer and have found great application in agricultural development, due to relatively easy access and ease of procurement. Humanure is one of those alternatives due to the fact that it could be readily available and cheap. Humanure is human fecal material and urine recycled for agricultural purposes. Human urine is an excellent soil fertilizer that is rich in nitrogen (N) while faeces are the solid or semi-solid remains of food which could not be digested in the small intestine but has been rotted down by bacteria in the large intestine (Hall *et al.*, 2011). It is rich in phosphorous (P) and potassium (K) (Jonsson *et al.*, 2005). Humanure are produced in different quantities and vary significantly in appearance (size, colour, and texture) according to the state of diet, digestive system and general health of the producer. Published figures indicate that more than one litre of urine is produced daily by an individual while less than 150g of faeces including moisture is produced daily by an individual (Wilkinson *et al.*,2009). The amount of urine is about 1-3 litres person^{-1} day^{-1} whose moisture content is 93-96%, dry matter content 50-70g person^{-1}day^{-1} depending on the meal habit of the producer There is 87% of N-content in urine, 11% in faeces and 50% of P-content in urine, 40% in faeces, 12% organic matter in urine, 47% in faeces and 99% of bacteria in faeces (Toilette du monde, 2009). Since humanure contains valuable plant nutrients, extensive research work has been conducted on effect of humanure on soil properties using types of vegetables and cereals. Wheat (Jonsson *et al.*, 2005), Cucumber (Ekpe *et al.*, 2017), Maize (Guzha *et al.*, 2005), Carrot (Mnkeni *et al.*, 2008) was found significant in improving the soil properties and yield of crops. According to Jenkins Joseph (2005), humanure excreta are not to be considered waste materials that need to be disposed off, they are resource materials that should be recycled and reclaimed for use. However, research projects have been conducted by international water management institute and partners since 2001 to provide information on the utilization of human excreta in agriculture. The organic matter and nutrients contained in excreta can be recycled and reused as fertilizer and soil conditioner an effect not shared by chemical fertilizer. Decomposed excreta improve soil structure, increase water holding capacity, reduce pest and diseases and neutralize soil toxins and heavy metals (Esrey *et al.*, 2001). It provides a rich growing medium or a porous absorbant material that holds moisture and soluble minerals providing the support and nutrients in which plants flourish although rarely used. The use of humanure can therefore result to improved agricultural production of subsistence crops, which would improve access to food through own production (Ekpe *et al.*, 2017).

Watermelon (*Citrullus lanatus)* is a fruit vegetable that belong to the Curcubitacea family (Adeyeye *et al*, 2016).The fruit is a warm season fruit which is cultivated in the warmer region of the Country. It is largely cultivated for its fruit pulp which is considered as a dessert rather than a vegetable (Longinus and Gilbert, 2013). The fruit has high water content which help in preventing dehydration during drought period and also help in food digestion (Sabo *et al*, 2013). It is highly nutritious and contains significant amount of sugar, vitamins A, B and C (Longinus and Gilbert, 2013). In addition to its delicious taste, it has high medicinal value for human beings. Watermelon fruit contain high level of lycopene that is very effective in protecting cells from damage and lower the risk of heart disease. The major constraints to watermelon production in this agro ecological zone include poor soil condition and insect pest infestation (Adeyeye *et al*., 2016).

Watermelon fruit are very good source of important nutritive components and contain a very high concentration of nutrients for human consumption. These exceptional qualities of watermelon and its relevance to human health that is chosen as a test crop in an experiment involving the assessment of the effect of humanure on soil properties at Fifty nine (59) days agronomic of watermelon in Owerri Imo State Nigeria.

2. MATERIALS AND METHOD

Site Description

The study was carried out at the Centre for Agricultural Research and Extension Farm, Federal University of Technology Owerri, from October 2019 to January 2020. The study site was located on latitude $5^0$23’4264”N and Longitude $6^0$57’4264”E. The study site had a humid tropical climate, annual temperature of 27-29^{0}and annual rainfall of 2,500mm (Okonkwo and Mbajiorgu, 2010).Which runs from March to December with its peak in July, through October and November. The dry seasons runs from December to March with a dry dust and cold intervals. The soil of the study area is classified as Ultisols using the USDA soil classification and Acrisol (FAO/UNESCO), (Eshett and Anyahucha, 1992).The Ultisols, (Acrisols in the FAO\UNESCO World Soil Map) are highly

ISSN 2347–3819 EISSN 2347–386X I OPEN ACCESS

acidic, coarse textured and highly leached upland soils. The soil has low mineral reserve and is therefore, low in fertility (Eshett, 1993).

Land Preparation

A total land area of 123.5m² (13×9.5) was used for the study. The experimental site was manually cleared using machetes, spade and hoe. Measuring tapes, pegs and ropes were used in mapping out the treatment plots. Fifteen experimental plots measuring 2.5m×2m was used for the experiment. Each plot was separated by 0.5m to prevent treatments from interfering with each other.

Experimental Materials and Treatments Allocation

Watermelon seeds (Kaolack Specie) and NPK fertilizer was sourced from Agricultural Development Program (ADP) Owerri Imo State, Nigeria. Humanure treatment was sourced from works layout Owerri and was cured for one month before application to the soil. The Treatments comprised of; T1-Control at 0t/ha, T2 - NPK` 20:10:10 at 240kg/ha, T3-Humanure at 10t/ha, T4-Humanure at 15t/ha and T5-Humanure at 20t/ha.

Experimental Design/Field Layout

The experiment was laid out in a randomized complete block design (RCBD) with treatments replicated three times as shown in figure 1.

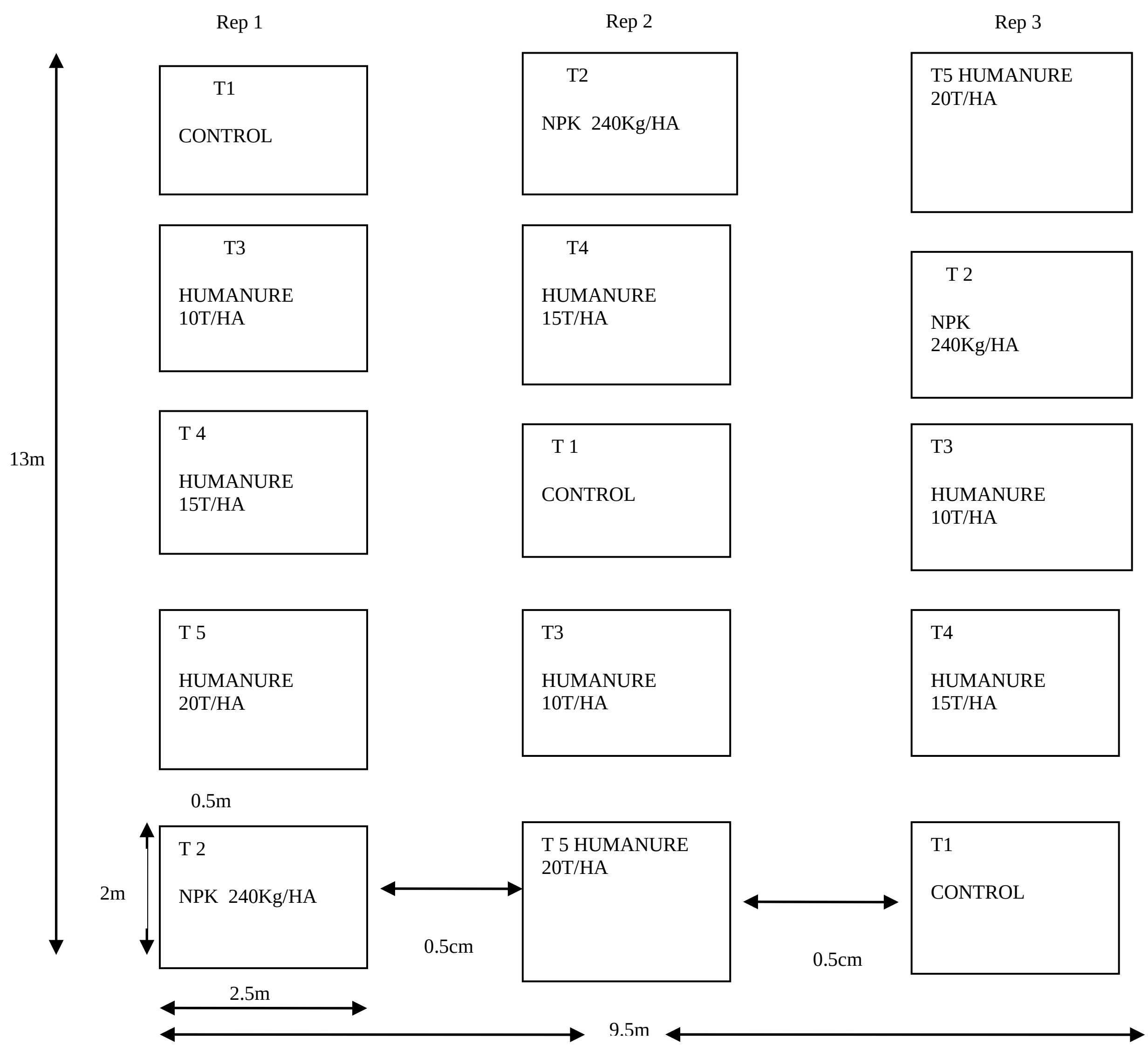

Figure 1: Field layout of the Experimental Site

ISSN 2347–3819 EISSN 2347–386X I OPEN ACCESS

Planting of Test Crop

Watermelon seeds (Kaolack specie) were sown by direct seedling two weeks after the incorporation of humanure treatment at the spacing of 70 cm x 70 cm and three seeds were per hole at the depth of 0-2cm to give a plant population of 120,000 seedlings per hectare. Weeding was carried out 2weeks after planting by hand picking and subsequently as regularly as the need arose. Liquid form of plant protectants Metazed 72 WP was applied to control pest and disease infestation. Watermelon fruits were harvested 75-80 days after planting when the leaf began to dry and the stalk turned brown (Oraegbunam *et al*, 2017).

Soil Sampling

Soil samples were collected at 0-30 cm soil depth using a core sampler attached to a soil Augar according to International Institute of Tropical Agriculture, 1975 method of free sampling. Samples collected were used for the determination of soil physical and chemical properties. The samples in the core samplers were first used for the determination of soil physical properties and was later air dried, crushed and sieved using 2mm sieve in preparatory for the determination of chemical properties.

Laboratory Analysis

The laboratory soil analysis was carried out at Soil Science Laboratory of Federal University of Technology Owerri, Imo State and the following soil properties were determined; Organic carbon was determined by the Walkley and Black (1934) wet-oxidation method as modified and described in manual of soil, plant and water analysis (Eno *et al*., 2009) and the value for organic matter was obtained by multiplying organic carbon value by 1.724 (Van Bemmelen factor). Available phosphorous was determined by Bray and Kurtz No.2 (1945) method adopted by Juo (1979) in which the phosphorous was extracted with 1ml NH_4F and 0.5ml Hydrochloric acid. Colour development was achieved by adding “reagent B”. Available phosphorous was determined calorimetrically using a photo calorimeter. Total nitrogen was determined by micro Kjeldahl digestion and distillation method of Bremner (1965) as recently modified and described in the manual of soil and water analysis (Eno *et al.*, 2009) using concentrated H_2SO_4 and a sodium copper sulphate catalyst mixture. Soil pH was determined in the laboratory with a glass pH meter at a ratio of 1:2.5 water ratios, exchangeable cations (Ca^{2+}, Mg^{2+}, Na^+ and K^+) were extracted with ammonium acetate solution, Exchangeable calcium and magnesium was determined by the ethylene diaminetetracetic acid titration method as described by Black (1965), whereas exchangeable potassium and sodium were determined by flame photometry method. Exchangeable acidity was determined by the titrimetric method Bray and Weit (1999). Total exchangeable acidity was determined by the summation of H^+ and Al^{3+}. Total exchangeable bases were determined by the summation of exchangeable cations (Ca^{2+}, Mg^{2+}, Na^+ and K^+). Effective Cation Exchange Capacity was determined by the summation of exchangeable acidity (Al^{3+} and H^+) and exchangeable bases. Percentage base saturation was calculated by the summation of the total exchangeable bases divided by effective cation exchange capacity and then multiplied by 100.

$$\%\ \mathrm{BS} = \frac{\mathrm{TEB}}{\mathrm{ECEC}} \times 100 \qquad \text{Equation (1)}$$

The Selected Physical Properties determined were**;** Bulk density was determined using core method (Black and Hartge, 1986).

$$\text{Bulk Density} = \frac{\text{Weight of wet soil} - \text{Weight of dry soil}}{\text{Weight of wet soil}} \times 100 \qquad \text{Equation (2)}$$

Total porosity was calculated from the result of bulk density and particle size density.

$$\text{Total Porosity} = \frac{1 - \text{Bulk Density (g/cm3)}}{\text{Particle Density}} \times 100 \qquad \text{Equation (3)}$$

Particle Size Distribution was determined by hydrometric meter in water and Calgon (Bouyocous, 1951). Soil texture was determined by matching the value of the particle size against the textural triangle. Gravimetric moisture content will be determined by the gravimetric method calculated mathematically as follows:

$$\%\ \mathrm{MC} = \frac{\mathrm{W2} - \mathrm{W3}}{\mathrm{W3} - \mathrm{W1}} \times 100 \qquad \text{Equation (4)}$$

Where MC = Moisture Content, W_1 = Weight of the core, W_2 = Weight of wet sample + core, W_3 = Weight of oven – dried sample + core.

ISSN 2347–3819 EISSN 2347–386X I OPEN ACCESS

The following agronomic parameters were determined; Vine length was taken by measuring with measuring with meter rule from the base of the plant to the apex leaf**.** The number of leaves were determined by counting all the leaves on the five tagged plants were counted and the total divided by five to give the average number of fruits per plant. Leaf Area was determined by measuring the length of leaf cm and breath of leaf cm of five tagged plants using a meter rule and multiplied by a factor 0.75 as recommended by Gomez (1972). Leaf Area Index was calculated using the formula below;

$$\text{Leaf Area Index (LAI)} = \frac{\text{Leaf Area}}{\text{Ground Area}} \qquad \text{Equation (5)}$$

Number of Leaves was determined by counting all the leaves on the five tagged plants and the total divided by five to give the average number of leaves per plant.

Statistical Analysis

Significant mean differences were detected using Fishers Least Significant difference at P = 0.05 according to Gomez and Gomez (1984).

3. RESULTS AND DISCUSSION

Soil Characteristics before Application of Humanure Treatment

The physical and chemical properties of the soil before application of humanure treatment at the experimental site are presented in Table 1.

Table 1: Pre-planting Soil Analysis

Soil Parameters and Units of Measurement	Value
Physical properties	
Sand (%)	92.28
Silt (%)	4.10
Clay ((%)	3.62
Textural class	Sandy soil
Bulk density (g/cm^3)	1.245
Moisture content (g/kg)	18.324
Particle density (g/cm^3)	2.65
Total porosity (%)	52.8
Chemical properties	
pH in H_2O (1:2:5)	5.86
pH KCl (1:2:5)	4.92
Organic Carbon (%)	1.216
Organic Matter (%)	2.096
Available phosphorous mg/kg	10.92
Total Nitrogen (%)	0.130
Calcium (Cmol/kg)	3.764
Magnesium (Cmol/kg)	1.810
Sodium (Cmol/kg)	0.048
Potassium (Cmol/kg)	0.031
Hydrogen (Cmol/kg)	0.500
Aluminum (Cmol/kg)	0.850
Exchangeable acidity (Cmol/kg)	1.350
Total Exchangeable Base (Cmol/kg)	5.653
Effective cation exchange capacity (Cmol/kg)	7.003
Percentage base saturation (%)	80.72

ISSN 2347–3819 EISSN 2347–386X I OPEN ACCESS

The result showed that the texture of the soil of the study site was sandy soil. This indicates that the soil of the study site was predominantly sandy and was well drained. The experimental soil recorded bulk density of 1.245g/cm^3 which was below the critical limit of 1.8 bulk density for sandy soils that restrict root growth and development (Hazelton and Murphy 2007). Total porosity of 52.8% was recorded in the experimental site. The soil was slightly acidic with pH of 5.86 in water and 4.92 in Kcl according to the critical values of 5.6 - 6.0 soil pH (Babalola *et al*, 1998). The soil pH value of 5.86 of the experimental site was within range for watermelon cultivation which is 5.0 – 7.0 (Ehiokhilem *et al*., 2017). The soil recorded low organic carbon content of 1.216%. This can be related to the findings of Patrick *et al*, (2013) that the threshold for soil organic carbon in tropical soils is 2% (20g/kg) and 3.4% organic matter (34g/kg) as a minimum value for maintaining stable soil structure. Available phosphorous was moderate and total nitrogen was low with values of 10.92mg/kg and 0.130g/kg respectively. Exchangeable Calcium was high and Magnesium was moderate with values of 3.764 and 1.810 Cmol/kg. While Sodium and Potassium were low with values of 0.048 and 0.031 Cmol/kg indicating that soil would be improved by addition of organic manure, so as to adequately support plant growth (Adelekan *et al*, 2010). Total exchangeable bases recorded 5.653 Cmol/kg while Exchangeable acidity recorded 1.350 Cmol/kg. Percentage base saturation and cation exchange capacity were moderate based on the standard rating of Babalola *et al*., 1998. The result indicates that the soil of the study site is low in fertility, therefore will be unable to sustain crop yield without human intervention.

Mineral Composition of Humanure Used in the Study

The mineral composition of the humanure used in the research is presented in Table 2.

Table 2: Mineral Composition of Humanure Used in the Study

Soil Parameters/Minerals	Values
pH in H_2O (1:2:5)	6.52
Organic Carbon (%)	18.92
Organic Matter (%)	32.6
Total Nitrogen (mg/100g)	456.0
Available phosphorous (mg/100g)	565.0
Calcium (Ca) (mg/100g)	530.0
Magnesium (Mg) (mg/100g)	190.0
Potassium (K) (mg/100g)	485.0
Sodium (Na) (mg/100g)	285.0

The result of the analysis of humanure used in the study recorded a pH value of 6.52 in H_2O which is adequate to support plant growth (Adelekan et al 2010). The organic matte content was high with value of 32.6% indicating that application of humanure to the soil will not only add nutrients to the soil but would also improve soil physical properties. Total Nitrogen, available phosphorous, potassium and sodium were high and this indicates that humanure would provide adequate nutrient needed for plant growth when added to the soil.

Soil Characteristics after Application of Humanure Treatment

Physical Properties

The result of the effect of humanure on soil physical properties at forty five (45) days after planting is presented in Table 3.

Table 3: Effect of Humanure on Soil Physical Properties at Forty Five (45) Days after Planting

Treatment	BD (g/cm^3)	TP (%)	MC (g/kg)	Sand (%)	Silt (%)	Clay (%)	Textural Class
T1	1.25^a	52.83^a	7.45^a	92.46	4.03	3.50	Sandy Soil
T2	1.25^a	52.90^b	8.01^b	92.40	4.20	3.30	Sandy Soil
T3	1.24^b	53.33^c	8.05^b	91.26	4.63	4.10	Sandy Soil
T4	1.23^c	53.56^d	8.33^c	90.63	4.80	4.13	Sandy Soil
T5	1.23^c	53.63^e	9.30^d	90.53	4.90	4.43	Sandy Soil
F-LSD P= (0.05)	0.001	0.055	0.064	NS	NS	NS	

Legend: BD = density, TP = Total porosity, MC= Moisture content, T1 = Control, T2= NPK= 240kg/ha, T3 = Humanure 10t/ha, T4 = Humanure 15t/ha, T5 = Humanure 20t/ha

Note: Figures with same superscript are not statistically significant.

ISSN 2347–3819 EISSN 2347–386X | OPEN ACCESS

Particle Size Distribution

The result of analysis of the effect of humanure on particle size distribution of the soil at forty five (45) days after planting showed that the soils were sandy. There were no significant differences in sand, silt and clay content of the soil. However, variations in values were observed when control was compared with treatments and when treatment was compared with one another. The control plot recorded 1.20, 1.83 and 1.93 more sand than 10t/ha, 15t/ha and 20t/ha humanure treated plots. The NPK treated plot recorded 0.24, 1.44, 2.07 and 2.17 more sand content than the control, 10t/ha, 15t/ha and 20t/ha humanure treated plots. The control plot recorded 0.17, 0.60, 0.77, 0.87 less silt content than the NPK, 10t/ha, 15t/ha and 20t/ha of humanure treated plots. The NPK treated plot recorded 0.43, 0.60 and 0.70 less in silt than the 10t/ha, 15t/ha and 20t/ha humanure treated plots. The 10t/ha humanure treated plot recorded 0.17 and 0.27 less in silt than the 15t/ha and 20t/ha of humanure treated plots. The control recorded 0.60, 0.63 and 0.93 less in clay content than the 10t/ha, 15t/ha and 20t/ha respectively. The NPK treated plot recorded 0.80, 0.83 and 1.13 less in clay than 10t/ha, 15t/ha and 20t/ha of humanure treated plot. The insignificant result observed with the humanure treated plots could be attributed to the fact that the soils originated from same parent material and soil organic amendments does not significantly change soil texture as it is a steady soil properties.

Bulk Density

The result showed that there were significant differences when control was compared with the humanure treated plots and when NPK treated plot was compared with the humanure treated plots. However, there was no significant difference when 15t/ha rate was compared with 20t/ha treatment. The control plot produced 0.01, 0.02, 0.02 more in soil bulk density when compared with 10t/ha, 15t/ha and 20t/ha humanure treated plot while the NPK treated plot produced 0.01, 0.02 and 0.02 respectively when compared with 10t/ha, 15t/ha and 20t/ha. The reduced bulk density observed in humanure treated plots compared with the control could be attributed to the increased soil organic matter from the humanure (Table 2). Organic matter can improve soil structure and aeration, reduce soil bulk density and increase microbial population which helps in aggregate formation and stabilization through the production of mucilage's that enhance the formation of soil aggregate (Atakora *et al*, 2014). The reduction of bulk density values in humanure amended soil portrays its environmental friendliness which is the reason for advocating its use for sustainable crop production (Ekpe *et al.*, 2017).

Total Porosity (%)

There was significant difference when humanure treated plots were compared with control plot and when the treatments were compared with one another in there % total porosity. The 10t/ha, 15t/ha and 20t/ha humanure treated plots produced 0.05, 0.73, and 0.80% higher TP when compared with TP from the control plot. When humanure treated plots were compared with NPK treated plot they produced 0.43, 0.66, and 0.73% high TP than the NPK treated plot. However when the % TP from the 20t/ha humanure treated plot was compared with 10t/ha and 15t/ha humanure treated plot, It produced 0.30 and 0.07% higher TP respectively, the improvement in soil total porosity in humanure treated plot might be as a result of improved soil particle aggregation brought about by improved soil organic matter content (Taiwo *et al*, 2017). The higher the soil total porosity, the lower the soil compaction. This increment in soil total porosity is in line with the findings of (Ekpe *et al.*, 2017) Agbede *et al.*, (2014), who noted that application of organic manure to the soil increased soil total porosity.

Moisture Content

The result showed that moisture held was statistically significant when control was compared with humanure treated plots and when the treatments where compared with one another. The control plot held 0.60, 0.88 and 1.85 less soil moisture compared with the 10t/ha, 15t/ha and 20t/ha humanure treated plot, respectively. The NPK recorded 0.32 and 1.29 less soil moisture content when compared with the moisture content from 15t/ha and 20t/ha humanure treated plots respectively. There was no significant difference observed when NPK treated plot was compared with 10t/ha humanure treated plot. However when humanure treated plots were compared with one another, 20t/ha held 1.25 and 0.97 more soil moisture than the 10t/ha and 15t/ha humanure treated plots. The higher moisture content held in the humanure treated plots could be attributed to increased soil organic matter from the humanure treatment, which enhances water infiltration and retention (Taiwo, 2017).

Chemical Properties

Results on effect of humanure on soil chemical properties at the forty five (45) days after planting is presented in Table 4.

ISSN 2347–3819 EISSN 2347–386X I OPEN ACCESS

Soil pH_w

Soil pH is a measurement of the hydrogen ion concentration of the soil solution. It is an important parameter indicative of the alkaline or acidic nature of the soil. The application of humanure treatment at 10t/ha, 15t/ha and 20t/ha statistically showed significant increase in soil pH when compared with the NPK treated plot and the control. Soil pH from the control plot recorded 0.12, 0.16, and 0.18 low soil pH_w than the humanure treated plots. When the humanure treated plots were compared with each other, there were no significant different observed when 15t/ha was compared with the 20t/ha. However, there was significant difference when 10t/ha was compared with the 15t/ha and 20t/ha. The 10t/ha humanure treated plot produced 0.04 and 0.06 lower pH_w than the 15t/ha and 20t/ha humanure treated plots. The decrease of soil pH_w by NPK treated plot may be explained by leaching of basic cations such as potassium, calcium and magnesium from the soil as a result of increased soil acidity (Han *et al,* 2016). This result is in agreement with the results of several studies which showed that organic manure treatment increased soil pH_w, but chemical fertilizer treatment such as NPK fertilizer decreased soil pH (Liu *et al.*, 2010, Han *et al.*, 2016).

Organic Matter

The result of the effect of humanure on soil organic matter showed that increasing humanure rate of application significantly increased soil organic matter content. The highest value of organic matter was observed in 20t/ha humanure treated plot. There was significant difference when control plot was compared with the treatments and when NPK treated plot was compared with the humanure treated plots. The humanure treated plot produced 2.94, 3.26, 3.47 more organic matter than control plot while NPK treated plots produced 2.66, 2.98 and 3.19 less organic matter than the 10t/ha, 15t/ha and 20t/ha humanure treated plot. There were also significant differences when humanure treated plot were compared with one another. The 20t/ha humanure treated plot produced 0.53 and 0.21 more organic matter than the 10t/ha and 15t/ha. The improvement of soil organic matter observed in humanure increased with increase in rate of humanure application and this is in line with the finding of Mona *et al*, (2013), Xin *et al,* (2016) and Suraji *et al,* (2015) who noted that increase in the quality of human excrete significantly increased soil organic matter content.

Total Nitrogen (%)

There were statistically significant differences in the value of the total soil nitrogen in the humanure treated plots when compared with the control plot and NPK treated plots and the humanure treated plots were compared with one another. The humanure treated plot produced 0.08, 0.13, 0.15 more soil nitrogen than those in the control plot. There were no significant difference observed when NPK treated plot was compared with 10t/ha humanure treated plot. However, significant difference were observed when NPK treated plot was compared with 15t/ha and 20t/ha humanure treated plot. The NPK treated plot recorded 0.02 and 0.07 lower nitrogen level than 15t/ha and 20t/ha humanure treated plot. Furthermore when the humanure treated plots were compared with one another, soil nitrogen increased with increased rate of application. This confirms similar results as reported by Tedasse *et al,* (2013), Ofori and Anning (2007) and Bationo *et al*, (2012). The marked changes observed in soil total nitrogen due to influence of humanure treatments may be attributed to the inherent high N content of the humanure (Table 2) incorporated and transformation during the composting in the soil.

Available phosphorous (P)

Application of treatments had significant effects on soils available Phosphorous. Soil available P was increased with increased rates of humanure application; there were significant differences when different rates of humanure treated plots were compared with the control. The control plot produced 6.47, 9.89, and 12.67 less available P content than the 10t/ha, 15t/ha and 20t/ha humanure treated plots. Also the NPK treated plot showed significant difference when compared with the humanure treated plots. The 10t/ha humanure treated plot produced 1.67 less in available P content that the NPK treated plot whereas the NPK treated plot produced 1.75 and 4.53 less available P content than the 15t/ha and 20t/ha humanure treated plots. When humanure treated plots were compared with one another 20t/ha had the highest increase in available P content. However soil available P content in the humanure treated plots increased with increased rate of humanure application. The available P content ranged from 10.53 to 23.20 mg/kg and was rated high according to the rating of Babalola *et al*, (1998) The increase in available P content observed in humanure amended plots agrees with the findings of Bationo *et al*, (2012), who noted that humanure when used as fertilizer usually stimulates microbial activities and thereby enhances the release of Phosphorous in the soil.

ISSN 2347–3819 EISSN 2347–386X I OPEN ACCESS

Table 4: Effect of Humanure on Soil Chemical Properties at Forty Five (45) Days after Planting

TRET	P^{H_W}	OC (%)	OM (%)	N (%)	AVP (mg/kg)	Ca^{2+} (Cmol/kg)	Mg^{2+} (Cmol/kg)	K^{+} (Cmol/kg)	Na^{+} (Cmol/kg)	H^{+} (Cmol/kg)	AL^{3+} (Cmol/kg)	TEA (Cmol/kg)	TEB (Cmol/kg)	ECEC (Cmol/kg)	BS%
T1	5.79^{a}	1.49^{a}	2.57^{a}	0.13^{a}	10.53^{a}	3.73^{a}	1.77^{a}	0.03^{a}	0.04^{a}	0.48^{a}	0.86^{a}	1.34^{a}	5.57^{a}	6.91^{a}	80.60^{a}
T2	5.57^{b}	1.65^{b}	2.85^{b}	0.24^{c}	18.67^{c}	3.74^{a}	1.80^{a}	0.07^{b}	0.06^{b}	0.46^{a}	0.91^{b}	1.37^{b}	5.67^{a}	7.04^{b}	80.53^{a}
T3	5.91^{c}	3.19^{c}	5.51c	0.21^{b}	17.00^{b}	4.11^{b}	1.94^{b}	0.07^{b}	0.08^{c}	0.55^{b}	0.74^{c}	1.29^{c}	6.20^{b}	7.49^{c}	80.77^{b}
T4	5.95^{d}	3.38^{d}	5.83^{d}	0.26^{d}	20.42^{d}	4.83^{c}	2.06^{c}	0.08^{c}	0.09^{d}	0.59^{b}	0.68^{d}	1.27^{b}	7.06^{c}	8.33^{d}	84.75^{c}
T5	5.97^{d}	3.50^{e}	6.04^{e}	0.28^{e}	23.20^{e}	5.14^{d}	2.26^{d}	0.10^{d}	0.12^{e}	0.55^{b}	0.64^{e}	1.19^{e}	7.62^{d}	8.81^{e}	86.49^{d}
F-LSD (0.05)	0.051	0.029	0.051	0.005	0.382	0.089	0.046	0.005	0.006	0.036	0.031	0.011	0.105	0.110	0.250

Legend: OC = Organic Carbon, OM = Organic Matter, N = Nitrogen, AVP = Available Phosphorous, Ca = Calcium, Mg = Magnesium, K = Potassium, Na = Sodium, H = Hydrogen, AL = Aluminum, TEA = Total Exchangeable Acidity, TEB = Total Exchangeable Bases, ECEC = Effective Cation Exchange Capacity, BS = Base Saturation, T1 = Control, T2= NPK= 240kg/ha, T3 = Humanure 10t/ha, T4 = Humanure 15t/ha, T5 = Humanure 20t/ha.

Note: Figures with the same superscript are not statistically significant.

Calcium (Ca)

The result showed that there were significant difference when the calcium content of the treated plots were compared with those from the control and when the humanure treated plots where compared with each other. The humanure treated plots produced 0.38, 1.10, and 1.41 Cmol/kg more calcium than the control plot respectively. Also when the NPK treated plot was compared with humanure treated plots, the NPK treated plot produced 0.37, 1.09 and 1.40 Cmol/kg less calcium content than the 10t/ha, 15t/ha and 20t/ha humanure treated plots. However when the humanure treated plot where compared with one another, 20t/ha humanure treated plot recorded the highest increase in calcium content. The increase in calcium content observed in humanure treated plots increased with increasing rate of humanure application. The calcium content of humanure treated plots was rated medium (2 – 5 mol/kg) according to the ratings of Babalola *et al*, (1998). The result obtained concured with earlier findings reported by Ekpe *et al*, (2017) who noted increased calcium content in soil due to application of humanure treatment.

Magnesium (Mg)

There were significant differences when the magnesium content of the control plot was compared with the humanure treated plots. The control plot recorded 0.17, 0.29, 0.49 Cmol/kg less in magnesium content than the 10t/ha, 15t/ha and 20t/ha humanure treated plots, respectively. Significant differences were also observed when the NPK treated plot was compared with humanure treated plots. The NPK treated plot recorded 0.14, 0.26 and 0.46 Cmol/kg less magnesium content than the 10t/ha, 15t/ha and 20t/ha humanure treated plot. However when the humanure treated plots where compared with one another the 20t/ha produced 0.32 and 0.20 Cmol/kg more magnesium content than the 10t/ha and 15t/ha humanure treated plot. The highest value (2.26 Cmol/kg) was observed in the 20t/ha humanure treated plot whereas the control plot recorded the lowest value (1.77 Cmol/kg). The increased magnesium content observed in humanure treated plot could be attributed to the high magnesium content in humanure released during mineralization. This result supports the findings of Nyakeoga, (2012) that organic waste added to the soil improved soil exchangeable bases.

Potassium (K)

The result of the effect of humanure on soil potassium showed that K content increased with increased rates of humanure treatment. There were significant differences when control was compared with the humure treated plots. The control plot produced 0.04, 0.05 and 0.07 Cmol/kg less K content than 10t/ha, 15t/ha and 20t/ah humanure treated plots. There was no significant difference observed when NPK treated plot was compared with 10t/ha, 15t/ha and 20t/ha humanure treated plot. Nevertheless, the NPK treated plot produced 0.01 and 0.03 Cmol/kg less in K content than the 15t/ha and 20t/ha humanure treated plot. Further more significant effects where observed when the humanure treated plots where compared with each other. The 20t/ha recorded the

ISSN 2347–3819 EISSN 2347–386X | OPEN ACCESS

highest K content in humanure treated plots. Potassium content in soil increased with increasing rate of humanure application. This could be attributed to the fact that human excrete (Table 2) have excellent plant nutrition value in terms of providing Nitrogen (N) phosphorous (p) and potassium (k) (kutu *et al.*, 2010).

Sodium (Na)

The Sodium content in humanure treated plot increased significantly over the control with application of humanure at various rate. The control recorded 0.04, 0.05, 0.08 Cmol/kg less sodium content than the 10t/ha, 15t/ha and 20t/ha humanure treated plots respectively. Significant difference was also observed when the NPK treated plot was compared with humanure treated plot. The 10t/ha, 15t/ha and 20t/ha humanure treated plots recorded 0.02, 0.03 and 0.06 Cmol/kg more sodium content than the NPK treated plot. However when the humanure treated plots where compared with each other, significant effects where observed. The 20t/ha humanure treated plots recorded the highest value (0.12 Cmol/kg) of sodium content. The 20t/ha produced 0.04 and 0.03 Cmol/kg more sodium content than the 10t/ha and 15t/ha humanure treated plot respectively. The result indicated that with the addition of humanure in the soil there was an increase in the sodium content in the soil.

Hydrogen (H)

Significant effects were observed in H^+ concentration when the control plot was compared with the 10t/ha, 15t/ha and 20t/ha humanure treated plots. The control produced 0.07, 0.11, and 0.07 Cmol/kg less hydrogen than the 10t/ha, 15t/ha and 20t/ha humanure treated plots respectively. There was no significant difference when the control plot was compared with the NPK treated plot. However, the NPK treated plot produced 0.09, 0.13, 0.09 Cmol/kg less hydrogen content than the 10t/ha, 15t/ha and 20t/ha humanure treated plot respectively. When humanure treated plots were compared with each other, no significant difference was observed in the 10t/ha and 15t/ha. The 15t/ha humanure treated plot recorded the highest value of hydrogen content in the soil.

Aluminum (Al)

The result showed that there was significant difference when the aluminum content of the control plot was compared with the other treatments and when the humanure treated plots were compared with one other. The humanure treated plots produced 0.12, 0.18, 0.22 Cmol/kg less in aluminum content control plot. Significant difference where also observed when NPK treated plot was compared with the control and the humanure treated plot. The NPK treated plot produced 0.05, 0.17, 0.23 and 0.27 Cmol/kg more in aluminum content than the control plot, 10t/ha, 15t/ha and 20t/ha humanure treated plots respectively. When the humanure treated plots were compared with one another aluminum content decreased with increasing rates of humanure treatment. The 10t/ha humanure treated plot recorded the highest value of aluminum when compared with the 15t/ha and 20t/ha humanure treated plot.

Total Exchangeable Acidity (TEA)

There were significant differences when the humanure treated plots where compared with the control. The 10t/ha, 15t/ha and 20t/ha humanure treated plot produced 0.05, 0.07, 0.15 Cmol/kg less TEA than the control plot respectively. Significant differences were also observed when NPK treated plot was compared with the control and the humanure treated plots. The NPK treated plot recorded more TEA than the control and 10t/ha, 15t/ha and 20t/ha humanure treated plots with values of 0.03, 0.08, 0.10 and 0.18 Cmol/kg respectively. Also there was significant difference when the humanure treated plots were compared with one another. The 15t/ha and 20t/ha produced 0.02 and 0.10 Cmol/kg less TEA than the 10t/ha humanure treated plot respectively. In addition, the humanure treated plots decreased in the TEA content with increasing rates of humanure application. This decrease observed in the humanure treated plots could be attributed to the ability of humanure to release basic cations on decomposition, thus precipitating $Al(OH)^3$, (Iroegbu *et al*, 2020).

Total Exchangeable Bases (TEB)

The result showed that TEB increased with increasing rates of humanure treatment application. Significant differences were observed when the control plot was compared with the humanure treated plots. The control plot produced 0.63, 1.49, 2.05 Cmol/kg less TEB than the 10t/ha, 15t/ha and 20t/ha humanure treated plots respectively. There was also significant difference when the NPK treated plot was compared with the control. In addition significant difference were observed when the NPK treated plot was compared with the humanure treated plots. The NPK treated plot recorded 0.53. 1.39. 1.95 Cmol/kg less TEB than the 10t/ha, 15t/ha humanure and 20t/ha humanure treated plot respectively. When humanure treated plots where compared with one another, significant differences were observed, while 20t/ha humanure treated plot recorded the highest value in TEB. Thus TEB increased

ISSN 2347–3819 EISSN 2347–386X I OPEN ACCESS

with increasing rates of humanure application. The increased soil TEB could be attributed to the greater capacity of nutrient retention of the amended soils. Similar results were reported by Udom *et al.,* (2017), Nyakeoga, (2012), Ekpe *et al.*, 2017).

Effective Cation Exchange Capacity (ECEC)

Application of humanure treatment at different rates significantly increased the soil ECEC when compared with the control. The 10t/ha, 15t/ha and 20t/ha produced 0.58, 1.42 and 1.90 Cmol/kg more ECEC content than the control plot respectively. There were also significant differences when the humanure treated plots were compared with the NPK treated plot. The 10t/ha, 15t/ha and 20t/ha humanure treated plot produced 0.45, 1.29 and 1.77 Cmol/kg more ECEC than the NPK treated plot respectively. However when the humanure treated plots where compared with one another, significant difference were also observed, the 20t/ha humanure treated plot produced the highest value of ECEC content. Whereas the 10t/ha and 15t/ha humanure treated plot produced 1.32 and 0.48 Cmol/kg lower ECEC than the 20t/ha humanure treated plot respectively. The soil ECEC increased as the application rates of humanure increased and this supports the findings of Angui *et al*, (2018) who noted that the higher the organic matter content, the high the ECEC and more nutrient retained in the soil for plant growth.

Base Saturation (%)

The result of analysis on base saturation showed that there was significant difference when the control was compared with the treatments and when the treatments were compared with one another. The control plot produced 2.17, 4.15, 5.89 Cmol/kg less in base saturation than the 10t/ha, 15t/ha and 20t/ha humanure treated plots respectively. There was no significant difference when the control was compared with the NPK treated plot. However significant difference was observed when the NPK treated plot was compared with 10t/ha, 15t/ha and 20t/ha humanure treated plots. The NPK treated plot recorded 2.24, 4.22 and 5.96 less in base saturation than the 10t/ha, 15t/ha and 20t/ha humanure treated plots. When the humanure treated plots were compared with one another, the 20t/ha humanure treated plot recorded the highest value whereas the lowest value was observed in the control plot. This shows that with the addition of humanure to the soil there was an increase in the percentage base saturation of the soil. Similar results were also reported by Ojobor *et al*, 2017 and Mona *et al*, (2013).

The Effect of Humanure on the Growth Parameters of Watermelon

The effect of humanure on the growth and yield parameters of watermelon are shown in Table 5.

Length of Vine (cm)

The result of the effect of treatments on vine length (cm) showed that significant differences were observed when the control plot was compared with the humanure treated plots. The control plot produced 13.97, 17.53 and 20.23 cm shorter compared with the 10t/ha, 15t/ha and 20t/ha humanure treated plots respectively. When the NPK treated plot was compared with the humanure treated plots, significant differences were also observed. The 10t\ha, 15t\ha and 20t\ha humanure treated plots produced 4.68, 8.23 and 10.94 cm longer vine than the NPK treated plot respectively. However when the humanure treated plots were compared with one another the 10t/ha and 15t\ha humanure treated plots produced 6.25 and 2.71 cm shorter vain than the 20t/ha humanure treated plot. The 20t/ha humanure treated plot recorded the longest vine of 76.50cm whereas the least value was recorded by the control plot with 56.27cm. The increased vine length with different rates of humanure treatment applied is in line with the findings of Emmanuella and Amon, (2018). This author noted that organic manure added to the soil supplied nutrients that enhanced vigorous growth which are important indices that culminate into increased fruit yield.

Number of leaves

The result of the effect of treatments on the number of leaves showed that there was significant difference when the number of leaves from the control plot was compared with the humanure treated plots and when the humanure treated plots were compared with one another. The control plot produced 2.24, 4.04 and 4.14 lower number of leaves than the 10t/ha, 15t/ha and 20t/ha humanure treated plots respectively. Also there was significant difference when the NPK treated plot was compared with the humanure treated plots. The humanure treated plots produced 1.67, 3.47 and 3.57 more number of leaves than the NPK treated plot respectively. When the humanure treated plots were compared with one another, there was no significant difference observed in the 15t/ha and 20t/ha humanure treated plots. Nevertheless, these values varied. The 10t/ha humanure treated plot recorded 1.80 and 1.90 fewer number of leaves than the 15t/ha and 20t/ha humanure treated plots. This result showed that there was an increase in the number of leaves of watermelon fruit when humanure treatment was added to the soil. Similar result was reported by Sabo *et*

ISSN 2347–3819 EISSN 2347–386X I OPEN ACCESS

al., (2013) who noted increase in vine length and number of leaves of watermelon due to increase in Nitrogen released during the mineralization of humanure treatment.

Table 5: The Effect of Humanure on the Agronomic Parameters of Watermelon

Treatment	Length of vain(cm)	Number of leaves	Leaf area (cm)	Leaf area index (cm)
T1	56.27[a]	17.76[a]	6.02[a]	4.82[a]
T2	65.56[b]	18.33[a]	7.29[b]	5.81[b]
T3	70.24[c]	20.00[b]	7.88[c]	6.31[c]
T4	73.79[d]	21.80[c]	8.86[d]	7.09[d]
T5	76.50[e]	21.90[c]	11.41[e]	9.13[e]
FLSD P=(0.05)	0.573	1.637	0.469	0.372

Legend: T1 = Control, T2 = NPK at 240kg/ha, T3 =Humanure at 10t/ha, T4 = Humaure at 15t/ha, T5 = Humanure at 20t/ha.
Note: Figures with the same superscript are not significant different.

Leaf Area (cm)

The result of the effect of treatments on leaf area showed that there was significant difference when the control plot was compared with the humanure treated plots and when the NPK treated plot was compared with the humanure treated plots. The control plot produced 1.86, 2.84 and 5.39 cm less in leaf area than the 10t/ha, 15t/ha and 20t/ha humanure treated plots respectively. When the NPK treated plot was compared with the humanure treated plots the NPK treated plot produced 0.59, 1.57 and 4.12 cm less in leaf area than the 10t\ha, 15t\ha and 20t\ha humanure treated plots respectively. However when the humanure treated plots were compared with one another, significant differences were also observed. The 10t/ha humanure treated plot recorded 0.98 and 3.53 cm less compared with the 15t/ha and 20t/ha humanure treated plots. The 20t/ha humanure treated plot recorded the highest value with 11.41cm in leaf area whereas the control plot recorded the least value with 6.02cm. This increment in the humanure treated plot could be due to the decomposition of the organic wastes and consequently its nutrient release which created a better soil environment for plants to take up nutrient. Similar result was reported by Oraegbunam *et al,* (2017).

Leaf Area Index (cm)

There was significant difference when the control plot was compared with the humanure treated plots. The control plot recorded 1.49, 2.27 and 4.31 cm less leaf area index than the 10t/ha, 15t/ha and 20t/ha humanure treated plots respectively. There was also statistical significant difference when the NPK treated plot was compared with the humanure treated plots, the NPK treated plot produced 0.50, 1.28 and 3.32 less leaf area index (cm) than the humanure treated plots respectively. However when the humanure treated plots were compared with one another, the 10t/ha humanure treated plot recorded 0.78 and 2.82 less in leaf area index (cm) than the 15t/ha and the 20t/ha humanure treated plots. The 20t/ha humanure treated plot recorded the highest value (9.13cm). The leaf area index increased with increasing rates of humanure treatment. The increased value of leaf area index in humanure treated plots could be attributed to the nutrient release rate of the different treated plots.

4. CONCLUSION

Application of humanure at different rates (10t/ha, 15t/ha and 20t/ha) at fifty nine (59) days improved soil physico-chemical properties and yield of watermelon when compared with the NPK and the control. The 20t/ha treatment had the highest effects in improving the soil physic-chemical and growth of watermelon compared with the control, NPK treated plot,10t/ha and 15t/ha humanure treated plots at the stage of growth. Therefore the use of humanure at the rate of 20t/ha could be adopted by farmers in Imo State and places with similar soil characteristics for better result of watermelon production. Though application of humanure at higher rates than 20t/ha can further be evaluated.

Conflict of interest

The authors declare that they have no conflict of interest.

ISSN 2347–3819 EISSN 2347–386X I OPEN ACCESS

Funding
There are no funding sources for this paper.

Ethical approval
This article does not contain any studies with human participants performed by any of the authors.

Data and materials availability
All data associated with this study are present in the paper.

REFERENCES AND NOTES

1. Adelekan B. A, Oluwatoyinbo F. I and Bamgboye A. I (2010). Comparative Effect of Undigested and Anaerobically Digested Poultry Manure on the Growth and Yield of Maize. Africa Journal of Environmental Science and Technology Vol 4(2) Pp.100-107
2. Adeyeye A. S, Akanbi W. B, Sobola O. O, Lamidi W. A and Olalekan K. K (2016): Growth and Fruit Yield of Watermelon (Citrullus Lanatus) As Influenced by Compost and NPK Fertilizer. FUW Trends in Science and Technology Journal. Vol 1 No 1, Pp80-83
3. Agbede T. M and Adekiya A.O, (2016). Effect of Cocao Pod Ash and Poultry Manure on Soil Properties and Cocoyam Productivity of Nutrient Depleted Tropical Alfisol .Http:// Doi.Org/10.5281/Zenodo.11/2187.
4. Agbede T.M, Adekiya A. O, Ogeh J.S (2014): Response of Soil Properties and Yam Yield to Chromolaenaodorata and Tithoriadiversifolia Mulches (Asteraceae) Mulches. Archives of Agronomy and Soil Science 60(2): 209-224.Dol: 10. 1080 /03650340 2013: 780127
5. Angui T. K. P, Kotaix A. J. A, Kassin N. E, Ngoram K. E Pierre Z. K and Bonfor B. (2018). Effect of Organic Fertilizer, (NPK 5-9-19) and (NPK 12-11-18) on Soil Chemical Properties in Tomato Crop In the South and Mid-West of the Ivory Coast. Journal of Soil Science and Environmental Management Volume 9 (7), Pp 108-118
6. Atakora K, Agyarko K, Asiedu E. K(2017): Influence of Grass Cutter, Chicken Manure and NPK Fertilizer on the Physical Properties of a Chromic Luvisol, Growth, and Yield of Carrot (Daycyscarita). International Journal of Plot and Soil Science 3(2): 197 -204. Dol: 109734 /IJPSS/2014/64/26
7. Babalola o, Babaji G. A and Mustapha S. (1998): Soil Management for Sustainable Agriculture and Environmental Harmony, Proceeding of the 24th Annual Conference of the Soil Science Society of Nigeria. Abubaka Tafawa Belewa University Bauchi, Nigeria.
8. Bationo, A., Fairhurst T., Giller K. E., Kelly V., Lunduka R., Mando A., Mapfumo, P., Oduor, G., Romney, D., Vanlauwe, B., Waireg,i L., Zingore S, (2012): African Soil Health Consortium: Handbook for Integrated Soil Management.
9. Black, C (1965). Methods of Soil Analysis Part 11 Chemical and Microbiological Properties. A M. Soc. Agron Inc. Publ. Madison, USA Pp 771-1572.
10. Black, G. R and Hartge G. A (1986). Bulk Density in Methods of Soil Analysis Part One American Society of Agriculture, Wiscosin, 374-398.
11. Bouyoucos G. H (1951). A Recalibration of the Hydrometer for Making Mechanical Analysis of Soils. Agronomy Journal 43,434-438.
12. Bray and Wait, R. R (1999). The Nature and Properties of Soil 12th Edition, Pp 12:446-489.
13. Bray, R. H and Kurtz, L. T (1945). Determination of Total Organic and Available Forms of Phosphorous in Soils. Soil Science Journal 59, 39-45.
14. Bremner, R. (1965). Fabric and Mineral Analysis for Soils New York: John Willy and Sons INC.
15. Eifediyi E. K, Ahamefula H., Oseghale E. S, Remison S. U Haruna B. O (2016). Growth and Yield Response of Garden Egg (Solanummelogena L.) to Neem Seed Cake Application Tropical Agriculture 93, 21-28
16. Ekpe I. I, Ihetuge, S. C, Okoye, C. Ahukaemere C. M, Onura M. D, Okere S. E and Nwaigwe M. O (2017). Effect of Humanure and Rumen Digesta on Soil Physio-Chemical Properties and Yield of Cucumber in Imo State South-Eastern Nigeria. Futo Journal Series (FUTOJNLS).Volume-3, pp 13-26.
17. Emmanuel M and Amon P. M (2018): Growth and Yield Performance of Watermelon during Dry and Weight Seasons Under Tropical Conditions, International Journal Of Vegetable Science, DOI:10:10:1080/19315260.2018.1439554.
18. Eno J. U, Trenchard, O. I, Joseph A. O, Anthony O. A and Ivara E. E (2009). Manual of Soil, Plant and Water Analysis. Sibon Books Limited Lagos ISBN 978-8012-71-X.
19. Eshett, E. T and C. N Anyahucha (1992). Effects of Low Lime Rates Application on Nodulation and Grain Yield of Cowpea (Vigna Unguiculata L. Walp) and Selected Biochemical Properties of Sand Ultisol in Owerri, South East Nigeria.

20. Eshette, E.T (1993), Wet Lands and Ecotone Studies on Land Water National Institute of Ecology, New Delhi And International Scientific Publication, New Delhi, Pp: 232-234.
21. Esrey, S. A and Adersson, I. (2001). Ecological sanitation closing the loop.
22. Gomez, A. K and Gomez, A. A (1984). Statistical Procedures for Agricultural Research Second Edition John Wiley and Sons Inc. New York, U.S.A 462.
23. Guzha, E., Nhap, I. Rockstrom J. (2005). An Assessment of the Effect of Human Faeces and Urine on Maize Production and Water Productivity. Physics and Chemistry of the Earth 30, 840-845.
24. Hall J, Guyton C. A (2011). Guyton and Hall Textbook of Medical Physiology (12th Edition). Philadephia Pa:Saunders\Elservier.
25. Han Si Ho, Ji Young An, Jaehong Hwang, Se Bin Kim and ByungBal Park (2016): The Effect of Organic Manure and Chemical Fertilizer on the Growth and Nutrient Concentrations of Yellow Poplar in a Nursery System, Forest Science and Technology 12:3, 137-143.
Hazalton P. A and Murphy B. W (2007): Interpreting Soil Test Results.University of Technology Sydney, Department of Natural Sciences.
26. IITA (1975). Institute for Tropical Agriculture Ibadan Nigeria Annual Report p.199.
27. Irogbu C. S, Asawalam D.O, Dada O. and Orji S. E (2020): Effect of Agricultural Wastes On Some Soil Physicochemical Properties of Ultisol, Growth Parameters and Yield of Cocoyam (Xanthosomamafafa) at Umudike, Southeasthern, Nigeria, African Journal of Agricultural Research Vol. 16(7), Pp. 952-962
28. Jenkins J. (2005), The Humanure Hand Book. A Guide to Composting, Humanure 3rd .Grove City, PA: Joseph Jenkins, Inc.
29. Jonsson H, Baky A., Jeppsson U., Hellstrom D and Karrmani E. (2005). Composition of Urine, Faeces, Grey Water and Bio-Waste for Utilization in the Unaware Model (Urban water Report 2005:6) Gothenburg: Chalmers University of Technology.
30. Juo, A.S.R (1979). Selected Methods for Soil and Plant Analysis International Institute of Tropical Agriculture (IITA) Ibadan Nigeria.
31. Kutu, F. R., Muchaonyerwa, P. and Mnkeni, P. N. S. (2010). Complementary Nutrient Effects of Separately Collected Human Faeces And Urine on the Yield and Nutrient Uptake of Spinach (Spinaciaoleracea). Waste Management and Research 29:532-539.
32. Lal R, (1993). Tillage Effects on Soil Degradation, Soil Resilience, Soil Quality and Stainability. Soil Tillage Red., 27:1-8.
33. Liu E, Yanc, Mei X, He W, Bing SH, Ding L, Liu Q, Liu S, Fan T. (2010). Long Term Effect of Chemical Fertilizer, Straw and Manure on Soil Chemical and Biological Properties in North West China. Geoderma 158(3): 173-180
34. Longinus A and Gilbert N (2013): Effects of Organic Manure Sources on the Growth and Yield of Watermelon in Abakaliki, South Easthern Nigeria. International Journal of Science and Research (IJSR) ISSN (Online):2319-7064
35. Mnkeni P. N. S, Kuku F. R, Muchaonyerwa P. and Austin L. M., (2008). Evaluation of Human Urine as a Source of Nutrients for Selected Vegetables and Maize under Tunnel House Conditions in the Eastern Cape, South Africa. Waste Management Research 26 (2), 132-139.
36. Mona EL- Ghany, Fawzy Abd, M - Attia and Khaled, S. M, (2013). Positive Effects of Organic Matter and Nutrients on Soil Properties, Microbial and Accumulation of Trace Elements on Crops Grown on Sludge Amended Soil. Journal of Applied Sciences Research 9(3):2244-2251.
37. Nwite J. N, (2015). Effect of Urine Source on Soil Chemical Properties and Maize Yield in Abakaliki, South Eastern Nigeria. International Journal of Advance Agricultural Research 3:31-36.
38. Nyakeoga K.V (2012): Evaluating the Agronomic Effectiveness of Human Faecal Compost on Maize Yields and Its Influence on Soil Chemical Properties and Soil Fauna Abundance.
39. Ofori J. and Anning D. K (2017): Influence of Composted Organic Waste and Urea Fertilization on Rice Yield, N-Use Efficiency and Soil Chemical Properties. West African Journal of Applied Ecology. Vol 25 (1), 2017 11 – 21
40. Ojobor S. A, Obiazi C. C and Egbuchua C.N(2017): Effects of Different Load of Compost Manure on Upland Rice and Soil Chemical Properties in Asaba, Delta State Nigeria. Vol 5, No 1, Pp 25-35. Global Journal of Agricultural Research.
41. Okonkwo G. I, Mbajiorgu C. C (2010). Rainfall Intensity-Duration-Frequency Analysis for South Eastern Nigeria. Agricultural Engineering International CIGR Journal 12:22-30
42. Oraegbunam C. J, Njoku O. M, Imoh O. N, Obalum S. E, Onyia V. N, Atugwu A.I and Uchida Y(2017): Agronomic Performance and Adaptability of Three Varieties of Watermelon (Citrullus Lanatus) on Sandy Loam Soil in Derived Savannah. Agro-Science Journal of Tropical Agriculture. Food, Environment and Extension Volume 15-(3) Pp.46-50
43. Sabo M. U,Wailare M. A,Aliyu M. Jari S and Shuaibu Y. M (2013). Effect of NPK Fertilizer and Organic Manure on Growth and Yield of Watermelon (Citrullus Lanatus) in Kaltungo Local Government Area of Gombe State, Nigeria Journal of Agricultural Science Vol 3(8).Pp 325-330

ISSN 2347–3819 EISSN 2347–386X I OPEN ACCESS

44. Suraji Mondal, R. D, Singh, A. K, Patra B. S, Dwivedi (2015). Changes in Soil Quality in Response to Short Term Application of Municipal Sewage Sludge Under Cowpea, Wheat Cropping System. Environmental Nanotechnology Monitori.
45. Tadesse T., Dechassa N, Bayu W and Gebeyehus (2013). Effect of Farm Yard Manure and Inorganic Fertilizer Application on Soil Physic-Chemical Properties and Nutrient Balance in Rain-Fed Low Land Rice Ecosystem. American Journal of Plant Science, 4: (02) 309-316.
46. Taiwo M. A, Aruna O. A and Ehiokhilen K. E, (2017): Impact of Poultry Manure and NPK Fertilizer on Soil Physical Properties and Growth and Yield of Carrot. Journal of Horticultural Research 2017. Vol. 25(1):81-88.
47. Toilettes Du Monde (2009). Guide Toilettes Searcher Assessment Eclologique Et Solidarite, Nyons, France, Pp 81
48. Walkley, A. J and Black I. A (1934). Estimation of Soil Organic Carbon by the Chromic Acid Titration Method Soil Science 29-38.
49. Wilkinson M. J., Crafford J. G., Jonsson H. and Duncker., (2009). Cost Benefits Analysis of the Use of Humane from Urine Diversion Toilets to Improve Subsistence Crops in the Rural Area of South Africa.
50. Xin X, Zhang J, Zhu A. and Zhang C. (2016). Effects of Long Term (23 Years) Mineral Fertilizer and Compost Application on Physical Properties of Fluvo-Aquis Soil in the North China Plain. Soil and Telliage Research, 156, 166-172

ISSN 2347–3819 EISSN 2347–386X I OPEN ACCESS